Magnetic Resonance in Chemistry 2018 vol.56 N2, pages 113-119

Dynamic properties of imidazolium orthoborate ionic liquids mixed with polyethylene glycol studied by NMR diffusometry and impedance spectroscopy

Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

Copyright © 2017 John Wiley & Sons, Ltd. We used1H pulsed field gradient nuclear magnetic resonance to study the self-diffusion of polyethylene glycol (PEG) with average molecular mass of 200 and ions in mixtures of PEG with imidazolium bis(mandelato)borate (BMB) and imidazolium bis(oxalato)borate ionic liquids (ILs). The IL was mixed with PEG in the concentration range of 0–100 wt%. Within the temperature range of 295 to 353 K, the diffusion coefficient of BMB is slower than that of the imidazolium cation. The diffusion coefficients of PEG, as well as the imidazolium cation and BMB anions, differ under all experimental conditions tested. This demonstrates that the IL in the mixture is present in at least a partially dissociated state. Generally, increasing the concentration of PEG leads to an increase in the diffusion coefficients of PEG and both the ions and decreases their activation energy for diffusion. Nuclear magnetic resonance chemical shift alteration analysis showed that the presence of PEG changes the chemical shifts of both ions but in different directions. Impedance spectroscopy was used to measure the ionic conductivity of the ILs mixed with PEG. Copyright © 2017 John Wiley & Sons, Ltd.

http://dx.doi.org/10.1002/mrc.4636

Keywords

chemical shift alteration, ionic conductivity, NMR diffusometry, nuclear magnetic resonance, pulsed-field gradient

References

[1] T. L. Greaves, C. J. Drummond. Chem. Rev. 2008, 108, 206–237.
[2] M. Petkovic, K. R. Seddon, L. P. N. Rebelo, C. S. Pereira. Chem. Soc. Rev. 2011, 40, 1383–1403.
[3] M.-D. Bermudez, A.-E. Jimenez, J. Sanes, F.-J. Carrion. Molecules 2009, 14, 2888–2908.
[4] A. E. Somers, P. C. Howlett, D. R. MacFarlane, M. Forsyth. Lubricants 2013, 1, 3–21.
[5] F. U. Shah, S. Glavatskih, O. N. Antzutkin. Tribology Lett. 2013, 51, 281–301.
[6] F. U. Shah, S. Glavatskih, D. R. MacFarlane, A. Somers, M. Forsyth, O. N. Antzutkin. Phys. Chem. Chem. Phys. 2011, 13, 12865–12873.
[7] M. Taher, F. U. Shah, A. Filippov, P. de Baets, S. Glavatskih, O. N. Antzutkin. RSC Adv. 2014, 4, 30617–30623.
[8] P. C. Nalam, J. N. Clasohm, A. Mashaghi, N. D. Spencer. Tribology Lett. 2010, 37, 541–552.
[9] R. Gusain, P. Gupta, S. Saran, O. P. Khatri. ACS Appl. Mater. Interfaces 2014, 6, 15318–15328.
[10] T.-Y. Wu, H.-C. Wang, S.-G. Su, S.-T. Gung, M.-W. Lin, S.-G. Su. J. Chinese Chem. Soc. 2010, 57, 44–54.

[11] H. Tokuda, K. Hayamizu, K. Ishii, A. B. H. Susan, M. Watanabe. J. Phys. Chem. B 2005, 109, 6103–6110.

[12] A. E. Frise, T. Ichikawa, M. Yoshio, H. Ohno, S. V. Dvinskikh, T. Kato, I. Furo. Chem. Commun. 2010, 46, 728–730.

[13] A. Filippov, F. U. Shah, M. Taher, S. Glavatskih, O. N. Antzutkin. Phys. Chem. Chem. Phys. 2013, 15, 9281–9287.

[14] S. Yu, S. Lindeman, C. D. Tran. J. Org. Chem. 2008, 73, 2576–2591.

[15] M. Golets, M. R. Shimpi, Y.-L. Wang, O. N. Antzutkin, S. Glavatskih, A. Laaksonen. Phys. Chem. Chem. Phys. 2016, 18, 22458–22456.

[16] T.-Y. Wu, H.-C. Wang, S.-G. Su, S.-T. Gung, M.-W. Lin, C. Lin. J. Inst. Chem. Eng. 2010, 41, 315–325.

[17] M. Moosavi, A. Daneshvar, J. Molec. Liquids 2017, 225, 810–821.

[18] J. G. Albright, L. Paduano, R. Sartorio, A. Vergara, V. Vitagliano. J. Chem. Eng. Data 2001, 46, 1283–1291.

[19] P. T. CallaghanPrinciples of Nuclear Magnetic Resonance Microscopy, Clarendon, Oxford, 1991, p. 492.

[20] J. E. Tanner. J. Chem. Phys. 1970, 52, 2523–2526.

[21] A. Filippov, N. Azancheev, M. Taher, F. U. Shah, P. Rabet, S. Glavatskih, O. N. Antzutkin. Magn. Reson. Chem. 2015, 53, 493–497.

[22] J. M. Dust, Z.-H. Fang, J. M. Harris. Macromolecules 1990, 23, 3742–3746.

[23] J. Malmstrom. Anal. Bioanal. Chem. 2012, 403, 1167–1177.

[24] Z. P. Visak, M. S. Calado, J. M. Vuksanovic, G. R. Ivanis, A. S. H. Branco, N. D. Grozdanic, M. L. Kijrvcanin, S. P. Serbanovic. Arabian J. Chem. 2014. https://doi.org/10.1016/j.arabjc.2014.10.003.

[25] S. Bhattacharyya, A. Filippov, F. U. Shah. Phys. Chem. Chem. Phys. 2016, 18, 28617–28625.

[26] S. Trivedi, S. Pandey. J. Phys. Chem. B 2011, 115, 7405–7416.

[27] A. Sarkar, S. Trivedi, G. A. Baker, S. Pandey. J. Phys. Chem. B 2008, 112, 14927–14936.